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ABSTRACT

This brief report examines various ways in which K-12 schools and institutions of higher education can collaborate to effect critical changes in teaching and learning through the use of computers. The first section briefly reviews the history of computer use in education, noting such critical needs as teacher training, and reviews the constructivist educational philosophy underlying technological collaboration efforts. In the second section some cutting edge programs in educating preservice and inservice teachers in computer technology are described. These include the Curry School of Education at the University of Virginia; the Discovery Center of the College of Staten Island (New York); the Mobile Laptop Computer Laboratory at the University of Missouri-Columbia; and the KidSat Project at the Jet Propulsion Laboratory (California). The third section focuses on the Space TREK Institute at Dana College (Nebraska) which offers teacher workshops on the educational applications of space shuttle simulation, geographic data, virtual reality imagery, and real-time meteorological information. This section also describes the principles of the teacher education model used at the institute. The next section offers examples of technological collaboration in educational restructuring efforts; a final section examines collaboration in the context of 21st century challenges. (Contains 19 references.) (DB)

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Technological Collaborations: K-12 and Higher Education

Kay McPherson Ferguson
O.W. Kopp

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Technological Collaborations: K-12 and Higher Education

by
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and
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Introduction

Technological collaborations between K-12 schools — even preschools — and higher education are on the frontier of schooling for the next millennium. Today's education no longer functions through a "give them the facts" model of instruction. Rather, instruction must be interactive, and that is where technology and technological collaborations can help.

A mere 20% of the workforce is employed in factories or agriculture. Fully half of today's workforce is employed in positions that call for gathering and processing information. Key skills are analysis, synthesis, and evaluation — all higher-level skills. These skills have replaced the "basics" of rote learning and simple application that once characterized most jobs. Consequently today's students — tomorrow's workforce — need schooling that engages them in active learning, team building, and problem solving. They need to practice higher-level thinking, and they need to use technologies that support both learning and work.

Technology already has reshaped business, industry, and the economy. It is essential in many aspects of life and work, from personal banking to medical research,

from global business to space exploration. Technology also has the power to reshape education and learning institutions, to enhance teaching and learning, to provide teachers and students with relevant worldwide connections with researchers and scientists, to empower youth and young adults to structure their own learning, and to provide teachers and professors with other models of teaching, learning, and assessment.

But U.S. Representative Constance A. Morella suggests:

> As we look to the major sectors of our economy, the educational system is the only sector that has not brought technology to bear upon its operations. And in a society so rich with information, we can no longer rely on skills appropriate only for the industrial age. (http://www.nap.edu/readingroom/books/techgap/welcome.html)

Thus two tasks must claim educators' attention. First, the information age requires an information model of education for both K-12 schools and institutions of higher education. Second, collaborative efforts by schools, colleges, and universities can accelerate the development of technology/teaching/learning models that will better prepare students for life and work in the information society.

In this fastback we examine how schools and higher education institutions can work together to bring about critical changes in teaching and learning. The focus in these collaborations is technology, particularly the use of computers in various ways.

The Computer: Symbol and Substance

The computer is the symbol of the information age, but it cannot be viewed as a panacea for all of the ills variously offered up by education's critics. Yet the computer — in all of its permutations — is very different from earlier forms of technology. Radio, motion pictures, and television were all, in turn, touted as technology that would transform education. None lived up to its advance billing.

All did have some effect on education, but none of these technologies "transformed" schooling in the ways that the computer can do — and is doing. One transformation that is being stimulated by the advent of computers is the closer tying of schools to institutions of higher education. But this change should not be overstated. Technology has not caused this change. Rather, it has accelerated it.

Fred Hechinger recently reminded educators that universities have been leaders in engaging in harmonious working partnerships with schools and have been leaders for change in the schools. He points out that in

1890 Harvard President Charles Eliot led a movement to allow more students to have access to a secondary education. Some 70 years later, in 1959, another Harvard President, James Conant, urged secondary schools to offer comprehensive programs that would meet the needs of students preparing for college and those entering the job market directly after high school (Hechinger 1995).

Through the years numerous partnerships have been developed. Hechinger also reports, for example, that the Yale-New Haven Teachers Institute recently pioneered a program to develop working relationships among university professors and classroom teachers to team teach using interdisciplinary models. However, unprecedented demands on the schools to prepare students for a technology-driven future and new pressures on professors to "ratchet up production" or possibly lose tenure have combined to create a sense of urgency about expanding such partnerships. The time is ripe for new and enlarged collaborations.

Playing Catch-Up

A decade ago the computer was a novelty whose relevance to the field of education had not been established. Consequently most practicing teachers had received little or no training in computer applications for teaching and learning. According to the U.S. Congress Office of Technology Assessment (OTA), in 1988 most teachers believed that they were inadequately prepared to use instructional technology. At that time only one-third of

K-12 teachers had received 10 or more hours of computer training (OTA 1988).

Education picked up on the computer's importance much more slowly than did other organizations, which produced about a 15-year lag that schools still are trying to overcome. But the catch-up activities have been largely unstructured and idiosyncratic. Public policy neglected schools and colleges, leaving them to find their own way through the technology maze (Fulton 1996).

The decade of the 1980s was a decade of mixed messages for most educators: Students should learn BASIC; nope, students should learn LOGO. Computer software was good only for drill and practice. All students should be taught keyboarding and word processing. It seemed that every year brought a new dictum to do this or that with the latest software. Stunned by conflicting messages, many educators made no advances at all, simply waiting for the last shoe to drop.

In 1995 the Office of Technology Assessment released a report on the effects of a decade of investment in education technology. According to OTA, fifth-grade students spent only 24 minutes each week using computers. That was for all subjects combined. Eighth-graders spent 38 minutes using computers, and high school juniors spent 61 minutes each week. Even more disturbing than the little time spent using computers was what the students used them for: drills in basic skills, instructional games, and word processing. Rarely was technology used to enrich content or truly enhance learning (Fulton 1996).

The OTA study also indicated that only 6% to 15% of school districts' technology budgets were used for

teacher training. Money went for hardware (55%), software (30%), and repairs (6%).

Sylvia Charp (1997) gathered information from several sources to examine some of the problems associated with technology use in schools. For example, a report from the Council of the Great City Schools Urban Technology Forum in March 1997 noted that:

- Teachers do not know how to integrate technologies into content areas or classroom activities.
- Most teachers do not understand technology and have to rely on a few experts for assistance.
- Teacher professional development workshops are often a one-time occurrence.

Information related to school-based use of the Internet also reveals problems. A Market Data Retrieval survey, "National Survey of Internet Usage: Teachers, Computer Coordinators and School Librarians, Grades 3-12," touched on some of them. This 1996-97 report indicated that 72.2% of the 6,000 surveyed Internet users report that they:

- Need more computers, modems, and phone lines in classrooms.
- Lack funding to pay the cost of online time.
- Need more training for teachers.
- Need material supporting content areas (Charp 1997).

These kinds of findings point out problems and challenges that higher education institutions can view as opportunities for collaboration. They need to do more than

just help schools catch up to technology use in business and industry. If schools are to teach for the future, they need to do more than catch up. They need to move ahead. They need to identify the cutting edge and get on it.

Of course, none but the most naive would assume that colleges and universities have all of the latest equipment or all of the answers. But many faculty members are highly knowledgeable about new technology, and that is sufficient to set the stage for productive collaboration between K-12 school people and educators at the postsecondary level.

Enhancing Learning

A word or two should be said about the philosophies that are implicit in the urge to collaborate. Numerous researchers and education leaders have indicated that more sophisticated learning occurs when: 1) teaching and learning are interwoven, 2) the learner participates in authentic learning environments, 3) the learning environments are designed for active student exploration and interaction, and 4) the learner can creatively apply new information.

Support for this view comes from many sources, including the early research of Jean Piaget. Piaget summarized several studies of children's conceptual development and found that children and youth who are engaged actively, rather than passively, better assimilate new information and develop higher-lever understandings. Piaget believed that to understand is to

invent, in other words, to "construct" meaning (Black and Ammon 1992).

Cognitive psychologists have turned overwhelmingly toward a constructivist view of learning (Anderson et al. 1995). Constructivist learning is concerned with understandings achieved through relevant, hands-on, engaging activities. Other education leaders who have been involved in revising frameworks and standards for learning also have based their suggestions on the constructivist model, "that learners do not passively absorb knowledge but rather construct it from their experiences" (Anderson et al. 1995).

According to Pepi and Scheurman, "Advocates of computer technology now tout computers and telecommunications as the primary, if not exclusive tools for implementing constructivist teaching methodologies" (1996, p. 231). Indeed, infusing a variety of technologies into the learning environment is a way to enhance learning through the use of relevant *computer-based* activities.

In a series of articles, Odvaard Dyrli and Daniel Kinneman, faculty co-directors of the Technology and Learning Professional Development Institute in Dayton, Ohio, discuss the benefits of infusing technologies into the curricula of America's schools. They suggest, "Multimedia in the classroom has the potential to enhance, enrich, extend, and ultimately transform the curriculum by creating authentic learning environments" (Dyrli and Kinneman 1995, p. 4).

For example, providing opportunities for students to conduct online research and creatively arrange information into a multimedia product is a constructivist

learning activity that is technology-dependent. Knowledge and understanding is constructed by the students, who are in control of locating, generating, and using text, graphics, images, animation, and sounds. Using technologies to access information globally stimulates learning and produces experiences that engage children and youth in creatively solving problems and thinking critically — all of which help to prepare them for a future in which global awareness and technological competence will be expected.

A New Role for the Teacher

The technology-driven model of constructivist teaching requires teachers to function as expert practitioners (with technology enabling them to collaborate regardless of geographic location) and students to function as apprentices with varying degrees of experience. Moving ahead educationally with multimedia in this way promotes collaboration among teacher and students, who employ technology to make learning more accessible, more meaningful, and more lasting.

Their work at the Technology and Learning Professional Development Institute prompts Dyrli and Kinneman to encourage schools to engage students and teachers in networking, global telecommunications, and multimedia as soon as possible. Multimedia, networking, and global telecommunications are keys to the future of educational computing. Teachers and students in any geographic location can access information easily and can communicate with researchers, scientists, and experts in any field.

Enabling students and teachers to connect to global information must be a major goal for educators. Hatfield notes that teaching is a complex, multidimensional process involving skills, knowledge, beliefs, decisions, and dynamic interactions occurring simultaneously. That complexity alone places extreme responsibilities on teachers. But additionally, teachers must possess a high degree of sophisticated knowledge, must adhere to a personal philosophy of education that places children and youth at the center of schooling, and must make creative decisions that often have long-term effects (Hatfield 1996). All of this responsibility argues for greater training support. In fact, Northrup and Little suggest, "The increased use of technology in K-12 classrooms has created a massive inservice training need in technology for practicing teachers" (1996, p. 216).

As much as this is true for practicing teachers, it also is true for teachers in training. The same burdens of teachers in the field, the same requirements, the same demands for excellence in teaching, are placed on preservice teachers. Thus the responsibility falls to institutions of higher education to train future teachers not to teach as their predecessors did, but to teach for the future. "Since teachers teach much as they were taught, university courses for prospective teachers must exemplify the highest standards for instruction" (National Research Council 1989, p. 65). Hatfield comments, "Preservice teachers need opportunities to construct their own knowledge, acquire new models of teaching, and analyze the teaching and learning process" (1996, p. 227).

Northrup and Little note that "an analysis of current technology-related research confirms the need for

teacher preparation programs to prepare pre-service and in-service teachers more effectively in the application and use of instructional technology" (1996, p. 216). Furthermore, 50% of teacher preparation programs indicate that technology should be seamlessly integrated into all coursework, thus making the need for a separate technology course obsolete (Roblyer 1993). This is a far cry from the early 1980s, when technology was viewed largely as an add-on. Unfortunately, technology is not "seamlessly integrated into coursework" in many higher education institutions — at least not yet.

A 1993 report from the Southeastern Regional Vision for Education (SERVE) called inservice training a key to teachers becoming technologically literate. The heaviest responsibility for providing inservice training has fallen naturally to higher education. Technology had not been — still is not in many institutions — central to teacher education. And so many new teachers have graduated and taken teaching positions in K-12 schools who have only limited knowledge about and experience with computer technology. While this is becoming less the case every day, it is still true even for many fairly recent graduates.

Therefore, higher education has a dual responsibility, working both with teachers who are already in the field and with future teachers. Technological collaborations often provide means to mingle these responsibilities.

Programs on the Cutting Edge

Around the nation there are programs committed to educating preservice and inservice teachers in the area of computer technology. These programs help teachers obtain a working knowledge of technology and the skills needed to infuse technology into the curriculum. Many of the programs can be emulated by schools and higher education institutions elsewhere.

The Curry School of Education

One collaboration worthy of note was developed by the Curry School of Education in Charlottesville, Virginia. The university spearheaded the development of a task force that included nine schools and colleges of education across the nation. The Educational Technology Taskforce concluded: "It is clear, then, that lack of appropriate training is a significant factor which has prevented integration of educational technologies into instruction both nationally and in Virginia" (Bull et al. 1994).

The Curry School task force developed a 10-year plan with a major goal of integrating technologies into the in-

structional process. The plan notes that technology has the potential to "revolutionize how teaching and learning occur in public schools . . . the student would have instant electronic access to the best teachers, exciting lessons, and the world's libraries of books, music, or film" (Bull et al. 1994). The long-range plan has propelled the project to train preservice teachers by designing experiences offering computing laboratory experiences with a field experience. Preservice teachers are immersed in instructional uses of such open-ended programs as HyperCard, ClarisWorks, and assorted telecommunications software. Preservice teachers are electronically linked with inservice teachers in the local Albemarle County and Charlottesville City schools. The partners collaborate as they explore how to infuse technologies into instruction.

Education majors take technology courses during the first three years of the five-year program. During the fourth year, educational technologies are infused into the various content areas, such as mathematics, language arts, and science. In the fifth year, students participate in a semester-long teaching internship. All of the placement schools are linked to a Public Education Network, thus permitting the intern, supervising teacher, and the faculty at the Curry School to confer electronically throughout the internship period. To date more than a thousand students have participated in the Curry School project.

In addition to the benefits for education students, the program benefits the school of education in two ways. First, by facilitating technology infusion efforts in local

schools, the program increases the likelihood that preservice teachers will work with teachers who routinely use educational technologies in the classroom. Second, the program also provides insight into the types of information that should be incorporated into preservice courses, by grounding such choices in uses of educational technology that have proven successful in the field (Bull et al. 1994).

The Discovery Center of the College of Staten Island

The collaborative technology model developed by Leonard Ciaccio and James Sanders, co-directors of the Discovery Center of the College of Staten Island (CSI), has been responsible for substantial improvements in student performance in K-12 schools. The directors work with the college's department of education and other departments to develop the entire college as a resource for improving teaching and learning in local school districts. More than 30 professors (13% of the college faculty) participate in the Discovery Center programs.

The focus of this project is the Discovery Model, which aims to make learning exciting. The Discovery Model uses student-centered, open-ended materials and hands-on activities that integrate themes that are relevant to adolescents. Early in the development of the model, the directors provided for collaboration between college faculty and high school teachers. This empowerment of participating teachers was essential to the success of the model and is a central tenet of all Discovery Center activities.

Another powerful component is the integration of current computer technology into all student-centered activities. "Computer software provides an environment where it is easy to revise ideas and perform varied types of analyses. Graphics and multimedia capabilities give students the ability to share a common visual representation of difficult concepts" (Carlin et al. 1997, p. 63).

The CSI campus has more than 40 classrooms with direct links to an audiovisual media center and provides for networking to all faculty and students with access to e-mail, CUNY library catalogs, CD-ROM tower, software, the Internet, and multimedia laboratories for authoring and producing assistive technology for students with disabilities. These resources have complemented the development of two additional projects, one focused on tech prep and one targeted for honors students.

The tech prep program is for low-income, disadvantaged, and underachieving students and provides exciting, relevant learning opportunities. The students enter the tech prep program at the end of their sophomore year of high school. The program prepares them to enter the two-year medical technology program at CSI, to go to another college, or to seek employment after high school. Teachers and students visit the CSI campus and computer laboratories, and students also serve apprenticeships in the community.

The Honors Research/Teaching Internship Program is for talented, achievement-oriented students, who participate in the program for three summers. Teachers and students attend workshops at CSI and work on research with CSI professors. The high school teaching

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interns use the knowledge they gain through the program's bi-monthly workshops during the school year to help their own teachers while they are still in high school.

Carlin and colleagues comment, "Technology is integrated into every aspect of these two programs" (1997, p. 63). Assessment of the programs has indicated that student performance improved and, in particular, that the teaching internship had a positive effect on the participants' writing skills. Investigators also noted that the teaching internships changed the honors students' attitudes toward teaching and motivated them to consider careers in teaching.

Mobile Laptop Computer Laboratory

The University of Missouri-Columbia College of Education is committed to producing a new generation of educators who are well-prepared to assist students in achieving higher levels of learning through computer technology. To this end the university opened a Mobile Laptop Computer Laboratory. Dean Richard Andrews writes that "the lab will allow graduates (future teachers) to know how to set up shop any place in the world and engage their students in technology enhanced learning" (1997, p. 48).

Through the combined resources of Computer Spectrum, Apple Computer, and Dayna Communications, each first-year education major is provided with a Macintosh PowerBook 1400cs and a collection of software. The university also developed software for

student use. This software, called the Interactive Shared Journaling System (ISJS), allows students to write journal entries and to send them electronically to a centralized server where others can review the entries and provide feedback. Additional university-developed, multimedia software includes tools for browsing the web, using e-mail, and interacting with news groups.

The Mobile Laptop Computer Laboratory project coincides with another new project called MOST, which stands for Missouri Supporting Teachers. James M. Laffey, a co-director of the Center for Technology Innovations in Education (CTIE), states that "The faculty of the college have put a priority on learning from field-based experience and developing reflective practice" (Andrews 1997, p. 48). MOST is spearheaded by CTIE for K-12 schools and is directed at improving mathematics and science instruction. The project is funded by a three-year grant from the National Science Foundation. Children in the participating schools maintain journals, much like the students in the College of Education.

The KidSat Project

The KidSat Project was designed by two astronauts, Sally Ride and JoBea Way, at the Jet Propulsion Laboratory in Pasadena, California. The project engages students in hands-on space exploration activities.

Participants in the program can gather images of the Earth using a computer link to a camera mounted inside the space shuttle. Middle school students select

where the photographs will be taken, which involves following the flight path of the shuttle, calculating the longitude and latitude of the region to be photographed, and determining the time the shuttle will fly over the region. "High school and university students then compile the requests into a single control file which is forwarded to the IBM Thinkpad connected to the Kodak electronic still camera. The Thinkpad automatically commands the camera to snap the pictures, which then are archived on a computer that students can access through the Internet" ("KidSat," 1997, p. 20). These images can be downloaded and printed for study in mathematics, science, social science, and English classes.

The KidSat project is a collaborative effort of the Jet Propulsion Laboratory, Johns Hopkins University Institute for the Academic Advancement of Youth, the University of California at San Diego, and TERC. The curriculum materials were developed by Johns Hopkins University Institute for the Academic Advancement of Youth.

KidSat was piloted in California and North Carolina and has been replicated in Millard Central Middle School in Millard, Nebraska, and Morgan State University in Baltimore. Programs have been established to train teachers to implement the KidSat Project at the Space TREK Institute at Dana College in Blair, Nebraska, and the University of Nebraska at Omaha. Space TREK is of particular interest, and so the following section provides a more detailed overview of this endeavor.

The Space TREK Institute

The Space TREK Institute was established in 1990 by the department of education at Dana College in Blair, Nebraska, located north of Omaha. TREK stands for Technology Resources Exciting Kids.

The institute has three goals: 1) to prepare preservice teachers to enter K-12 classrooms ready to use technology in the teaching and learning process, 2) to provide technology inservice workshops to teachers already in the field, and 3) to improve the quality of education for Nebraska's children and youth, with extended application to other participants from across the nation.

Since the institute was founded, it has continually expanded to meet the growing needs of teachers and students. For example, the institute brings 100 children from Nebraska and other states to the institute for two weeks. Teachers who attend two-week institutes have the option of extending their stay for an additional week.

Participants learn how to fly the Horizon Space Shuttle Simulator (described below), and master teach-

ers conduct workshops to model effective teaching practices. Teachers selected to participate in the Space TREK Institute are paid a stipend and given room, board, print materials, and software. They and the students attend workshops conducted by nationally known, award-winning instructors. Following are descriptions of four of the workshops.

Horizon Space Shuttle Simulator. In a replica of the space shuttle, participants take on various roles as astronauts and mission control personnel. Video cameras monitor activity inside and outside the shuttle, and the simulated windows on the flight deck display images of Earth as seen from space. Participants at the 14 computers solve problems, conduct experiments, and record data as they launch the shuttle, fly the mission, and then land. All of the participants are linked through headsets and their computers, which also are connected to the Internet. World Wide Web sites and HyperStudio stacks provide information during the mission.

To add to the verisimilitude, participants wear replica NASA space vests; and the launch, flight, experiments, landing, and debriefing sessions are based on actual NASA missions. Both students and teachers attend workshops to practice pre- and post-flight activities and to learn how to use sophisticated technology. Primary themes woven into the space simulation include the use of math and science skills, solving problems, and thinking creatively.

Virtual Nebraska-Virtual America. Participants get an eagle's eye view of America in this workshop for stu-

dents, teachers, and teacher trainees. The workshop uses digital data developed by the United States Geographic Survey, the Jet Propulsion Laboratory, and NASA.

Participants study the world from space by downloading images from KidSat data systems; and they use the downloaded images to study Earth in an integrated curriculum that includes social studies, language arts, mathematics, and science.

Teachers in this workshop also produce space education materials by using web-deliverable information and working in conjunction with the Calmat Center at the University of Nebraska-Lincoln, the Jet Propulsion Laboratory, and NASA.

Virtual Reality Imagery. Children and adults create 3D digital images and animations of locations on Earth and Mars, which correspond to activities in the Horizon Space Shuttle Simulation. For example, digital photography is used to create QuickTime virtual reality movies of landscapes.

Additional information and images are collected using CD-ROM and the Internet. Both teachers and students create animations and multimedia projects, which are saved in personal portfolios that can be used when they return to their own schools.

Sky View. This workshop is designed to develop an intuitive connection between weather experienced on the ground and large-scale atmospheric changes that can be observed using Earth-orbiting weather satellites.

Using real-time meteorological information obtained through the Internet, participants analyze current at-

mospheric dynamics and conditions and relate them to conditions viewed on the Earth's surface. Participants are introduced to various meteorological concepts and techniques for forecasting future atmospheric conditions. Special attention is given to the forecasting needs of a successful space shuttle mission.

These workshops model ways in which the institution of higher learning can construct and provide environments in which teachers and students feel comfortable and can learn together. They also represent highly effective collaborative efforts among classroom teachers, college and university professors, and preservice teachers. Assessment data indicate that teacher participants 1) acquire technological proficiencies, 2) develop classroom activities that incorporate a variety of technologies, 3) work comfortably with students and other teachers, 4) readily reverse teaching and learning roles with students, and 5) later replicate shuttle launches in their classrooms.

TREK Teacher Education Model

The TREK Teacher Education Model (TTEM) is continually evaluated and redesigned according to assessments made during the Space TREK Institute. For example, a comparison was made between teachers who attended the institute for one week (Group A) and teachers who attended a second week (Group B). The Group B teachers attended the second week in order to work with 100 children. The researchers found that the addition of the students to the training program produced significant differences in the learning experience for teachers.

Teachers in Group B were anxious about the arrival of the children, afraid they would not know how to use the technology and the software or how to operate the shuttle and mission control. Thus they put in extra time and effort, going to the computer labs early in the morning (before breakfast) and working there until midnight. Teachers pressured themselves to learn new skills. As a result, Group B teachers achieved significantly higher levels of proficiency than Group A teachers on the following characteristics:

- Teachers transferred technology knowledge and skills learned at the institute into classroom activities and curricular areas.
- Teachers gained confidence in their abilities to use technologies in their classroom.
- Teachers demonstrated overall confidence in applying technology to mathematics, social science, language arts, and science activities.
- Skills acquired at the institute propelled the teachers to become trainers for other teachers, often becoming the "resident experts."
- Teachers taught their students to author multimedia products to document students' newly acquired knowledge and research.
- Teachers developed and used a network system with other teachers, the TREK instructors, and Dana College education faculty.
- Teachers crusaded for and obtained from their districts equipment, software, and connectivity to the Internet, so that they could implement their newly acquired knowledge and skills.

- Teachers were eager to present at workshops and local, state, and national conferences.

Dana College preservice teachers remain an integral part of the Space TREK Institute. Many attend the one-week workshops with a group of selected teachers. During the second week they are responsible for an assigned group of students and thus become a part of the teaching/learning team. These preservice teachers are prepared to incorporate technology into instructional activities, design multimedia products, access resources from the Internet, prepare homepages for the World Wide Web, and involve children in active learning.

During the academic year, these preservice teachers are placed in leadership roles and serve as trainers for other education majors. They also conduct pre- and post-flight workshops and shuttle launches for groups of students and teachers who visit the shuttle *Horizon*. The Dana College TREK Teacher Education Model has become an effective model for the infusion of technology into the K-12 classrooms.

Technology and Restructuring Instruction

While technological literacy has been called the "new basic" in American education, general lack of support has limited its proliferation and application. "Public policy has neglected classroom teachers — leaving them to find their own way in a jungle of changing technologies and a maze of changing expectations" (Fulton 1996, p. 76). In fact, there is little, if any, public policy support for technological change for school districts, community colleges, or four-year institutions. The absence of policy support is felt in inadequate financial support for changes that technology might bring to schools.

For example, many schools and institutions of higher education lack the electrical wiring and telephone lines necessary to connect to the Internet. A 1995 report from the National Center for Education Statistics revealed that 46% of schools (35,700 schools serving 19.3 million students) lack electrical wiring for telecommunications

technology and 55.5% of the schools (42,700 schools serving 22.5 million students) do not have the telephone lines necessary for modems that would be used to connect to the Internet. The situation is worse in urban centers, where 60% of schools report insufficient wiring, telephones, modems, and other devices necessary to fully use available technology (OTA 1995).

However, the situation is not hopeless. Policy work is going on. In particular, President Clinton's New School Construction Initiative supports a vision of advanced technological connectivity. The goal of this initiative is to connect all K-12 classrooms to the information highway by the year 2000. This initiative has four pillars: computers, connectivity, curriculum, and competence. In practical terms, the initiative calls for: 1) training and support for teachers to help students learn to use computers and the information highway, 2) development of effective and engaging software and online resources, 3) access to modern computers for all teachers and students, and 4) connectivity for every school and classroom to the Internet.

Bolstered by presidential support, more than 2,000 volunteers marked California's Net Day on 9 March 1996 by installing and testing six million feet of wire in thousands of schools to connect classrooms to the Internet. Since that day more than 30 states have followed suit, initiating efforts to replicate this endeavor. Furthermore, to extend this initiative, the President has proposed the creation of a $2 billion, five-year Technology Literacy Challenge Fund, designed to stimulate state, local, and private-sector projects along these lines.

Growing Collaboration

Collaborations between higher education institutions (both two- and four-year) and K-12 schools are slowly but persistently developing. Apart from limited policy involvement and problematic financing, the greatest stumbling blocks have been entrenched attitudes. On one hand, university professors tend to take a deficit view of K-12 preparation. The professor's plea of "just teach them more about my discipline" is still prevalent. On the other hand, K-12 teachers tend to see colleges and universities mainly as degree-granters whose focus is less student-oriented intellectual growth than it is "jumping through hoops" progress through a set curriculum. Fortunately, both viewpoints are changing; and technology has been a motivator. A comment in one journal seems particularly telling: "Students who grow up in a technological age will not accept lectures that fail to draw upon the information resources on the Internet and elsewhere" (Educom 1996).

In many schools fourth-graders are designing their own virtual reality and multimedia products to display the results of research. They are actively involved in structuring their own learning. By the time they reach high school, such students already will be experts in creating documents with newly generated information that they have found in CD-ROM and online sources. When they graduate from high school, these students will be looking for colleges and universities where technologically enhanced learning not only is available but

is better than they had in their high schools. And student use of technology, however limited, is growing. That growth is pushing schools and higher education institutions alike.

Another perspective is that of faculty recruitment in higher education. Institutions where hardware and connectivity are behind the times cannot hope to attract outstanding faculty, in particular new faculty members who have experienced advanced technology. This also is becoming a factor in recruitment at the K-12 level, as new teachers seek positions in schools and districts where the technology matches their experience and expectations.

Yet another factor pushing collaboration between K-12 and higher education is the prevailing notion that all levels of education must prepare students to be lifelong learners. Technology is paramount in reaching this goal. In the information age no learner can "opt out" of technology. The computer is omnipresent, and everyone must learn how to drive on the information highway. More important, the bridge from the 20th century to the 21st century also is a bridge between distant lands, distant cultures, and distant economies. The information highway is global.

For education, whether K-12 or higher, the global information highway also means that distance learning is becoming an international reality. School districts are sending and receiving courses around the world, making it possible for schools in remote areas to offer to their students classes that would not otherwise be feasible. Undergraduate and advanced degrees increasingly can

be obtained through distance learning. Online, interactive classes can be received in centers, workplaces, or at home — and they create a virtual reality with vivid content using colorful graphics, full-motion video, sound, and animation. In many cases, schools and higher education institutions can collaborate on distance learning programs that will benefit both students and community members who want to participate in continuing education.

An excellent example of an all-ages distance learning opportunity is the collaborative effort called "Let America Speak." In this online project, Patrick Henry and Thomas Jefferson debate the role of the federal government. Students participating in this project then can speak to other students in various states and to historians. High school students and their teacher in a classroom in one state, for example, might confer with college students and their history professor in another state.

The demand for technology-driven collaborations creates a concurrent demand for inservice training. Schools, school districts, and higher education institutions also can collaborate to the benefit of teachers at all levels. The benefits are greatest when such professional development attends to educators' pedagogical, curricular, and emotional support needs. And support must come both from experts and colleagues if it is to be truly valuable.

For colleges and universities that seek to initiate collaborations with K-12 schools, there are signposts to success. We have observed that the most successful collaborations incorporate most, if not all, of the following characteristics:

- The higher education institution developed a program that was of interest and value to K-12 educators.
- The institution reached out to K-12 educators, assessed their needs, valued their opinions and suggestions, and tapped into their expertise.
- The institution and the K-12 educators created a true partnership and saw that partnership as crucial to success.
- The program focused on the practical, rather than the theoretical, and emphasized classroom application.
- K-12 teachers implemented and extended their new knowledge in classroom teaching.

One signpost to success cannot be overemphasized: Collaboration requires a milieu of cooperation among professional equals. The second and third items in the preceding list point up this factor. Those in higher education must view K-12 teachers as true partners in learning and working. K-12 collaborators must feel that their knowledge, experience, and contributions are valued. And they must be committed to take what they learn and put it to use in their schools and classrooms. Thus the extension of the teachers' commitment to learn and use new knowledge must be the school's, the university's, and the community's commitment to provide the technological tools to make implementation possible.

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Challenge for the 21st Century

At 12:01 a.m. on the first day of January 2001, when the new century begins, the slate will not be clean. We often speak of meeting the challenges of the 21st century as if, when we stand on the threshold of the new millennium, we will be able to dust off our hands and say, "Well, that's done!" Not so. Reality dictates a different scenario.

The future is about possibilities. Even as close as we are to the start of the 21st century, many changes still may occur before that threshold is crossed. Technology advances at incredible speed, making monumental strides almost overnight. Even the acknowledged computer gurus have difficulty keeping pace. The more advanced technology becomes, the wiser we must be in using technology in ways that improve and enhance human learning.

The connectivity that has become possible — indeed, impossible to avoid — as a result of technology must be mirrored in collaborative connections between K-12 and higher education. We all must prepare our students

for a global, interactive community; for the diversity and complexity of life and work in the 21st century; and for lifelong learning that will enable them to deal with technological advances in the future. We cannot undertake these Herculean tasks alone. Collaboration is essential.

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